

# DEPARTMENT OF THE INTERIOR WEATHER PROGRAMS

The Interior Department (DOI), is the nation's principal conservation agency, charged with the mission "to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities." The following operational and research programs contribute to the Federal Meteorological Plan.



## UNITED STATES GEOLOGICAL SURVEY (USGS)

### WATER DATA.

The USGS's Water Resources Discipline (WRD) collects streamflow, precipitation, water quality, ground-water level, and other water resources and climatological data as part of a national network and for a number of projects concerning rainfall runoff, water quality and hydrologic processes. Currently, the USGS collects hydrologic and meteorological data from more than 11,000 surface-water sites, precipitation data from more than 1,100 sites, ground-water level data from more than 23,000 sites, and water quality data from more than 8,900 surface-water, ground-water, and precipitation sites.

Data collected at USGS sites are transmitted from approximately 7,100 remote Data Collection Platforms (DCPs). The data are transmitted to Wallops, Virginia, via GOES and rebroadcast to a domestic communication satellite (DOMSAT). Data are received from the DOMSAT by local readout ground stations (LRGS) procured by USGS. The USGS currently operates 25 LRGS which provide near-real-time data to the USGS's computerized National Water Information System (NWIS). Data from over 1,800 additional sites are transmitted via other telemetry (mostly telephone). Near-real-time streamflow data and ancillary information are provided to National Weather Service River Forecast Centers for about 3400 river fore-

cast points (Figure 3-DOI-1).

The USGS also collects precipitation samples in a number of studies for the determination of atmospheric contribution to the chemical constituent loads to runoff, and for defining the effect of atmospheric deposition on water quality and the aquatic environment.

The USGS serves historical and real-time water resources data on the Internet at its NWIS Web site (<http://water-data.usgs.gov/nwis/>).

### SNOW AND ICE STUDIES.

The USGS is carrying out a joint research program with NASA, the University of Washington-Seattle's Electrical and Civil Engineering Departments, and the French Space Agency (CNES) to measure snowpack water equivalent or snow depth using

satellite passive microwave observations from the Defense Meteorological Satellite Program's (DMSP) Special Sensor Microwave/Imager (SSM/I) sensor. Unlike observations in the visible bands, passive microwave observations are independent of cloud cover and solar illumination and respond to both snow depth and snowpack grain size. The investigation is developing techniques to utilize algorithms that include the effects of grain size metamorphoses and to incorporate these algorithms into hydrologic models. Analysis of the two decade long passive microwave data set for the northern hemisphere snow covered extent has shown that the maximum snow pack has decreased in area and the global snow season is getting shorter, except for northeastern Canada.

The USGS and the BLM have used a

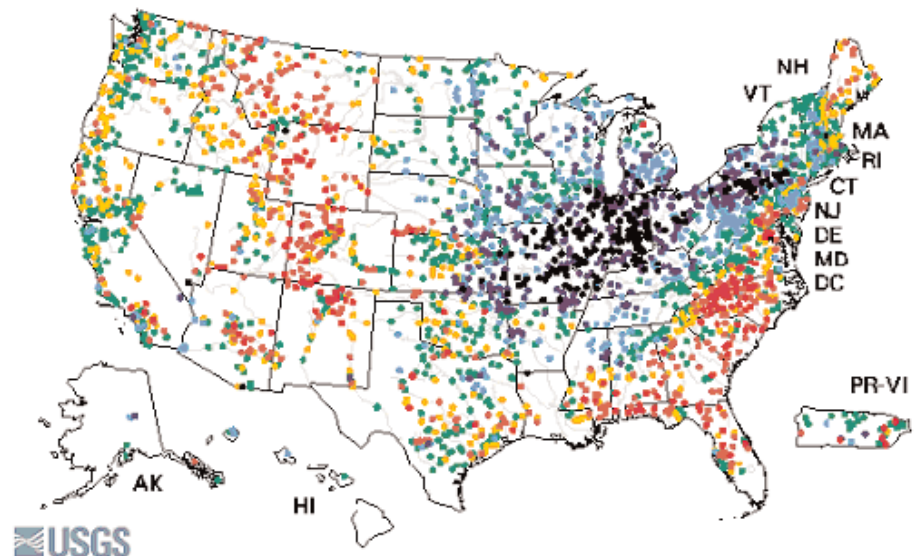


Figure 3-DOI-1. Sample USGS Water Watch map of real-time streamflow compared to historical streamflow for the day of the year. Source: USGS Web-site: <http://water.usgs.gov/waterwatch/>

combination of Landsat-7 and synthetic aperture radar images of the Bering Glacier, Alaska, which surged in 1993-95, to map the retreat of the glacier terminus as it undergoes large scale disarticulation. Scientists use these data to monitor the level of Berg Lake and the integrity of the ice dam that forms the southern shore of the lake, to assess the potential hazard presented by an outburst flood. In addition, the imagery is being used to plan summer field programs that include hydrographic investigations in expanding Vitus Lake, and both aquatic and terrestrial sampling.

#### CLIMATOLOGICAL RESEARCH.

USGS also carries out research in climate change, regional hydrology, the carbon cycle, coastal erosion, volcanic activity, and glaciology. As part of its glaciology program, the USGS maintains an observation program on three benchmark glaciers representative of different climactic zones of the western United States, one in Washington, one on the south coast of Alaska and one in the interior of Alaska. At each glacier, the program measures the winter snow accumulation, summer snow and ice ablation, air temperature, and runoff in the glacier basin. Beginning in 1959, this is the longest such record in North America. Analysis of this record is providing a greater understanding of the climate variability and its effects on water resources of the western United States.

The record clearly shows the effects of changing winter precipitation patterns associated with atmospheric conditions in the northeast Pacific Ocean, including El Niño - La Niña events and the Pacific Decadal Oscillation. Analysis of South Cascade mass balance data and NCEP re-analysis data for the northeast Pacific Ocean shows a strong relationship between winter balance and the temperature and on shore moisture flux and between the summer balance and the local temper-

ature, which have been used to examine the effects of future climate scenarios on glacier mass balance.

#### GEOMAGNETIC DATA.

The Geomagnetism Program (<http://geomag.usgs.gov>) of the USGS Central Region Geohazards Team provides real-time, ground-based measurements of the Earth's magnetic field, which are an important contribution to the diagnosis of conditions in the near-Earth space environment of the sun, the solar wind, the magnetosphere, the ionosphere, and the thermosphere. During geomagnetic storms, brought about by the complex interaction of the Earth's magnetic field with that of the Sun's, both high- and low-frequency radio communications can be difficult or impossible, global positioning systems (GPS) can be degraded, satellite electronics can be damaged, satellite drag can be increased, and astronauts and high-altitude pilots can be subjected to enhanced levels of radiation.

Ground-based geomagnetic observatory data are complementary to those collected by space-based satellites; indeed, most of the hazardous effects on technological systems brought about by magnetic storms occur at or near the Earth's surface. Therefore, the Geomagnetism Group monitors the surficial magnetic field by operating 14 magnetic observatories in the United States and its Territories. The data from these observatories, plus 15 foreign observatories, are transmitted to the Group's headquarters in Golden, Colorado, where they are processed and analyzed. Data are then transmitted to the Space Environment Center (SEC) of the National Oceanic and Atmospheric Administration (NOAA) and to the U.S. Air Force (USAF) Air Force Weather Agency at Offutt AFB, Nebraska.

USGS observatories are operated in cooperation with Intermagnet, an international consortium overseeing the operation of nearly 80 geomagnetic

observatories distributed around the globe. The roles and responsibilities of agencies participating in the National Space Environment and Warning Program are detailed in the *National Space Weather Program Strategic Plan* (FCM-P30-1995).

#### VOLCANOLOGY AND VOLCANIC ASH PLUMES.

The USGS participates in the Working Group for Volcanic Ash (WG/VA) of the OFCM. This working group is preparing a *National Framework for Volcanic Ash Hazards to Aviation*. Through its Volcanic Hazards Program, the USGS is responsible for monitoring volcanoes in the United States and issuing eruption forecasts and notifications.

When Mount St. Helens, WA, reawakened in September 2004, from an almost 15 year sleep, the eruptions have largely consisted of the extrusion of lava with activity confined to the crater. However, periodic explosions have erupted ash to heights as great as 30,000 feet above sea level. The USGS, NWS, and FAA have worked together to develop procedures and protocols to handle an erupting volcano situated between two major metropolitan centers.

Of the approximately 70 historically active volcanoes in the United States, more than 40 are in Alaska. Until the 1980's, the Alaskan volcanoes had been largely unstudied. Despite Alaska's low population density over much of the state, Alaska's volcanoes underlie the heavily traveled air routes of the North Pacific region. During recent years, the USGS's Alaskan Volcano Observatory (AVO) has expanded its network of real-time seismic monitoring stations to bring 27 of Alaska's volcanoes under continuous real-time surveillance. Data and information from the AVO monitoring activities are integrated directly into the regional operational activities of the FAA, DOD, and NOAA/NWS to provide

warnings for pilots and aircraft operators in the Alaskan region. For much of the late spring-early summer 2004, and January-February 2005, Veniaminof volcano on the Alaska Peninsula frequently erupted ash to heights approaching 12,000 feet above sea level. USGS worked with NWS and FAA to establish an appropriate response to Veniaminof's low-level, but frequent activity

Internationally, the OFCM's WG/VA supported expansion of USGS monitoring activities in the remote Pacific Rim of explosive volcanoes. The 100 historically active volcanoes in Alaska, Kamchatka, and the Kuriles are monitored through satellite imagery several times a day. Currently, about 220 aircraft per day - carrying about 20,000 passengers and millions of dollars of cargo value -- fly international Northern Pacific Routes near these historically active volcanoes. About half these flights are United States carriers. AVO, through its working agreement with the Kamchatkan Volcanic Eruptions Response Team (KVERT) in Petropavlovsk-Kamchatsky, Russia, also supplies information about eruptive activity in Kamchatka and the Kuriles to the FAA, the NWS, and numerous domestic and foreign air carriers.

In 2003, the USGS responded to the eruption of Anatahan Volcano in the Northern Marianas, a Trust Territory of the US, which affected aviation flying across the Pacific. A small monitoring system installed in 2003, has enabled USGS scientists to provide notification of significant changes and eruptions to FAA, NOAA, and US Air Force as activity at Anatahan has continued.

The USGS, OFCM, and other US and international sponsors organized the Second International Conference on Volcanic Ash and Aviation Safety on 21-24 June 2004, in Alexandria, VA. The conference was a 4-day assembly of the international aviation, governmental, and scientific commu-

nity involved with the ash issue. The conference was a forum to exchange technical and operational information, with the goal of identifying ways to improve mitigation of the ash hazard to aviation. The agenda included a combination of plenary sessions, poster presentations, and informal discussions on the topics of eruption monitoring and reporting, ash-cloud detection and forecasting; case histories of encounters and operational solutions, Volcanic Ash Advisory Center operations, the needs of the aviation industry, and education and outreach. More detailed information about the conference is on-line at [http://www.ofcm.gov/homepage/text/spc\\_proj/volcanic\\_ash/volash2.html](http://www.ofcm.gov/homepage/text/spc_proj/volcanic_ash/volash2.html)

## BUREAU OF LAND MANAGEMENT (BLM)

The BLM is one of five Federal Land Management agencies which have centralized wildland fire weather operations at the National Interagency Fire Center (NIFC), in Boise, Idaho. The BLM's Initial Attack Management System (IAMS) was designed in the mid-1980's to provide real-time data access and modeling for the fire management organization. The IAMS required a considerable dedicated

telecommunications network for data distribution. In an effort to reduce these inherent telecommunications costs, the BLM has moved into a "web server" environment. Many of the capabilities that were centrally located in the old IAMS have been moved to other web sites.

## FIRE WEATHER WEBSITES.

The principal Wildland Fire Management Information System (WFMIS) inputs remain the same with Remote Automatic Weather Station (RAWS) and National Lightning Detection Network (NLDN) information (Figure 3-DOI-2). BLM's new server system is called the BLM Wildland Fire Management Information Site ([www.nifc.blm.gov](http://www.nifc.blm.gov)). Additional fire management information is summarized and made available at the Desert Research Institute ([wrcc.dri.edu](http://wrcc.dri.edu) and [cefa.dri.edu](http://cefa.dri.edu)) and the United States Forest Service Wildland Fire Assessment System ([//svinet2.fs.fed.us/land/wfas/](http://svinet2.fs.fed.us/land/wfas/)). Additionally, the BLM has utilized the Desert Research Institute's capabilities to respond quickly for website support.

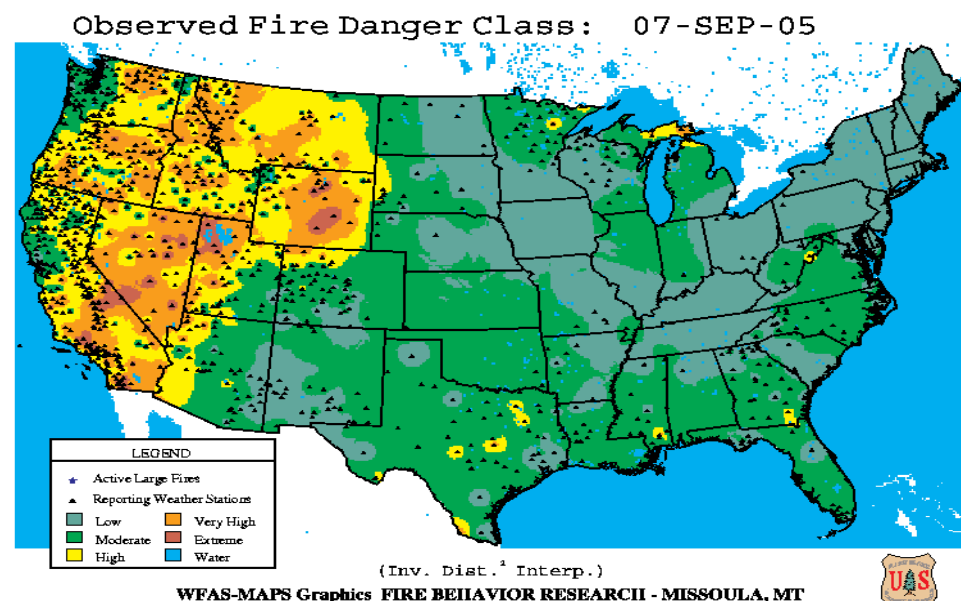


Figure 3-DOI-2. A National Interagency Coordination Center (NICC) graphic of Observed Fire Danger Class for the lower 48 states.



## AUTOMATED WEATHER STATIONS.

The BLM's RAWS Program primarily collects meteorological data for fire weather forecasting. However, use of BLM's RAWS data set by other non-fire users has generated sufficient funding to permit year-round operation of the entire network. The BLM's Resource Management and Oregon O&C (West-Side) also operate RAWS networks which are much smaller and have specific program requirements that differ from fire management.

## LIGHTNING DETECTION.

In 1997, the BLM began contracting with a private vendor via the National Weather Service for lightning location data. Data are received at the NIFC in Boise, Idaho, and placed on the BLM WFMIS for qualified user access. Current plans are to continue the operation of the Alaska Automatic Lightning Detection System as an independent government-owned and operated system.

## FIRE WEATHER SUPPORT.

The BLM's Remote Sensing / Fire Weather Support Unit (RSFWSU) at NIFC provides the full range of program management, equipment dispatch, field and depot maintenance, support and data services for the BLM and numerous other government agencies. This interagency-staffed and funded facility performs work under long term agreements with those agencies within the government having similar equipment and requirements.

## CLIMATE MONITORING.

In addition to the meteorological monitoring BLM conducts primarily to support wildland fire management activities, the BLM also conducts site-specific climate monitoring at over 200 manual weather station locations on the public lands in the 11 western states and Alaska. The operation of these sites ranges from seasonal to

annual, taking measurements of precipitation, temperature, soil moisture, and other meteorological parameters necessary to assess local climatic influences. These data are primarily used for natural resources management and planning at the local level.

## PORTABLE WEATHER STATION.

During the 1999 fire season, the Remote Sensing/Fire Weather Support Unit (RSFWSU) began a 2-year "proof of concept" effort with a portable weather station referred to as the Fire RAWS (FRWS). FRWS are intended for use on or near a fire line and can be rapidly relocated to points desired by Fire Behavior Analysts for real-time weather data. Due to the extreme fire season in both 1999 and 2000, the FRWS was used extensively and was found to be a valuable asset for firefighter safety and fire weather forecasting. Fire managers have also increased the use of FRWS to monitor intentionally-initiated prescribed burns.

Currently, 33 FRWS systems are cached at NIFC for use during the

2005 season. FRWS collect, store, and forward data by interrogated voice radio with new data available every fifteen minutes. Satellite data can be retrieved from the BLM/NIFC website, and hourly satellite data is available to Fire Weather Forecasting Staff for spot forecasts and fire support from all central locations (Geographic Area Coordination Centers, NIFC, etc.).

## ALL RISKS SUPPORT.

After the terrorist attack on September 11th, 2001, the RSFWSU was tasked to provide near real-time meteorological data collection at the World Trade Center (Figure 3-DOI-3). This effort was in direct support of the Environmental Protection Agency's task of monitoring air quality in the vicinity of the collapsed towers. The unit also provided remote meteorological support for the Columbia Shuttle accident investigation and recovery effort, and RAWS support has generated interest from the Department of Homeland Security as it assesses its needs for remote and urban environmental monitoring. Using the person-



Figure 3-DOI-3. Remote Sensing/Fire Weather Support Unit providing near-real-time meteorological data collection at the World Trade Center.

nel and resources available at the RSFWSU, the BLM can offer a rapid meteorological support capability that is unique across the federal government.

## **BUREAU OF INDIAN AFFAIRS (BIA)**

The Bureau of Indian Affairs collects atmospheric data to evaluate potentially irrigable Indian Trust lands in the Southwest. The Bureau also collects and shares fire weather data with other Federal agencies while participating in fire management activities for local and interagency use.

Currently, BIA operates the following instrumentation:

- 69 fire weather RAWS stations (permanent stations),
- 5 "manual" weather stations,
- 13 portable RAWS stations used for Prescribed Fire, and
- 10 RAWS deployed on emergency stabilization projects.

## **MINERALS MANAGEMENT SERVICE (MMS)**

The Minerals Management Service (MMS) gathers offshore meteorological data for use in the management of offshore oil and gas resources. The data are used in air quality and oil-spill modeling, model development, and other research projects. Currently, MMS is funding operation of two offshore meteorological buoys in the Gulf of Mexico. Support for one of the

buoys will be discontinued in FY 2006. The MMS also utilizes data from other buoys funded by NOAA. The buoys collect air temperature, sea surface temperature, wind direction, wind speed, wave height, and wave spectrum data. Many of the buoys measure relative humidity as well.

MMS operates a profiler at the Louisiana Universities Marine Consortium (LUMCON) facility in Cocodrie, Louisiana (Figure 3-DOI-4). The profiler has been collecting data since October 2004, and will be operating for a three-year period. Data collected at this site may be accessed at <http://weather.lumcon.edu/weather-data/doppler>. The data collected will be applied to regional models for evaluating impacts from emission sources on ozone, fine particulate matter, and regional haze. The MMS is also planning to install a profiler at the Pensacola Naval Air Station in the Florida Panhandle. The profiler is expected to be installed and operational in the summer of 2005.

Another meteorological data collection effort is ongoing in the Beaufort Sea in Alaska, where six meteorological stations have been collecting data since 2001 (see <http://www.resdat.com/mms/>). Data collection by these stations will continue in FY 2006. The information will be applied to oil spill modeling and air quality impact evaluations.

MMS has a cooperative agreement with the Coastal Marine Institute (CMI) at Louisiana State University for a study to assess meteorological influences on visibility offshore Louisiana. This study is expected to be completed in FY 2005. In a cooperative agreement with the CMI at the University of Alaska, MMS is sup-

porting a meteorological modeling project for the Cook Inlet and the Shelikof Strait in Alaska. This project is also being concluded in FY 2005.

The MMS is currently conducting a study entitled *The Breton National Wilderness Increment Analysis*. This study consists of a meteorological and air quality modeling analysis in and around the Breton National Wilderness Area (NWA), which is a Class I area under the Clean Air Act (CAA), and as such is afforded special protections under the Prevention of Significant Deterioration (PSD) provisions of the CAA. The Breton NWA is located on a chain of barrier islands off southeastern Louisiana. The objective of the study is to assess the impacts of Outer Continental Shelf (OCS) oil and gas production activities on the PSD increment consumption. This effort is expected to be completed in FY 2006. Copies of final reports on past meteorological and air quality studies in the Gulf of Mexico may be found at [http://www.gomr.mms.gov/homepg/regulate/enviro/techsumm/rec\\_pubs.html](http://www.gomr.mms.gov/homepg/regulate/enviro/techsumm/rec_pubs.html).

The MMS is also conducting a study entitled *Development of a Next generation Air Quality Model for OCS Applications*. The model being generated is an enhanced version of the CALPUFF air quality model that is better adapted for over water use. The model will contain improved formulation of the marine boundary layer and over water dispersion. The model will be able to be linked to output from the Pennsylvania State University / National Center for Atmospheric Research mesoscale model (MM5), as well as additional prognostic models such as the Rapid Update Cycle (RUC), Eta, and the Regional Atmospheric Modeling System (RAMS). The model is projected to be completed by the end of FY 2005.

## **NATIONAL PARK SERVICE (NPS) AND FISH AND WILDLIFE**



Figure 3-DOI-4. The MMS Profiler at LUMCON facility in Cocodrie, Louisiana.



## SERVICE (FWS)

The National Park Service monitors air quality and visibility in a number of national parks and monuments. Gaseous pollutant data are collected on continuous and integrated (24-hour to weekly) bases. Surface meteorological data are collected and analyzed for hourly averages. Precipitation chemistry is determined on week-long integrated rainfall samples. Twenty-four hour, average particle concentrations (mass, elemental analyses, some chemical constituent analyses) are measured every third day. Atmospheric light extinction is measured continuously and relayed to a central location for analyses.

## MODELING

The NPS also conducts and contracts research to develop and test air quality models to assess long-range transport, chemical transformation, and deposition of air pollutants. These models are used to estimate source contributions to, and to identify source regions responsible for, observed pollutant loadings.

## JOINT MONITORING AND RESEARCH

The Fish and Wildlife Service

Air Quality Branch and the NPS Air Resources Division operate under an interagency agreement and are collocated in Lakewood, Colorado. Expertise from both agencies is pooled to address the air quality issues that are the responsibility of the Assistant Secretary of the Interior for Fish and Wildlife and Parks.

The NPS oversees the operation of the Interagency Monitoring of Protected Visual Environments (IMPROVE) network and the IMPROVE Protocol network in cooperation with the Environmental Protec-

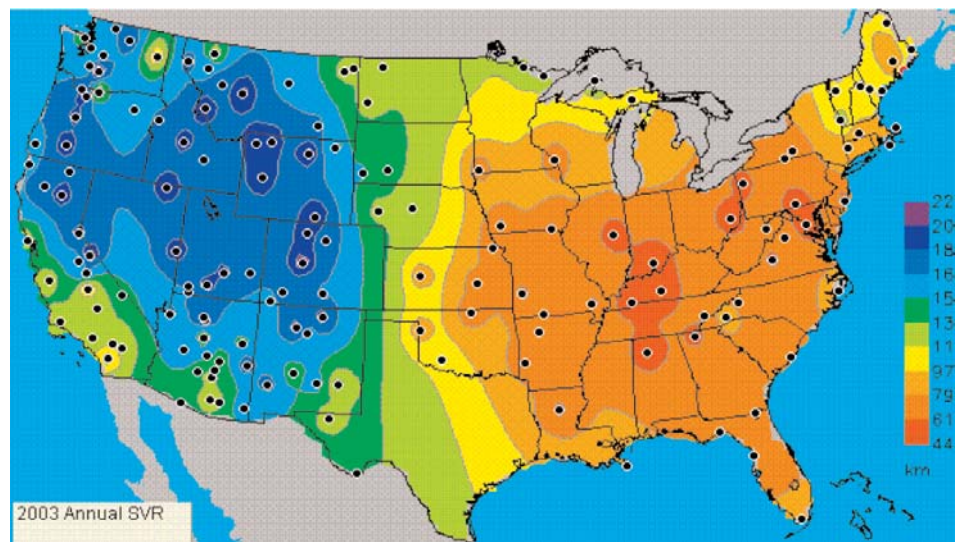


Figure 3-DOI-5. Map of annual average standard visual range (SVR), in kilometers, calculated from IMPROVE particle concentrations. Also shown are the locations of most of the IMPROVE and IMPROVE protocol sites during 2003. <http://vista.circa.colostate.edu/views>

tion Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the United States Forest Service (USFS), the FWS, the BLM, and various State organizations. Since 2000, the networks have been expanded to over 170 sites, mostly through funding provided by the EPA

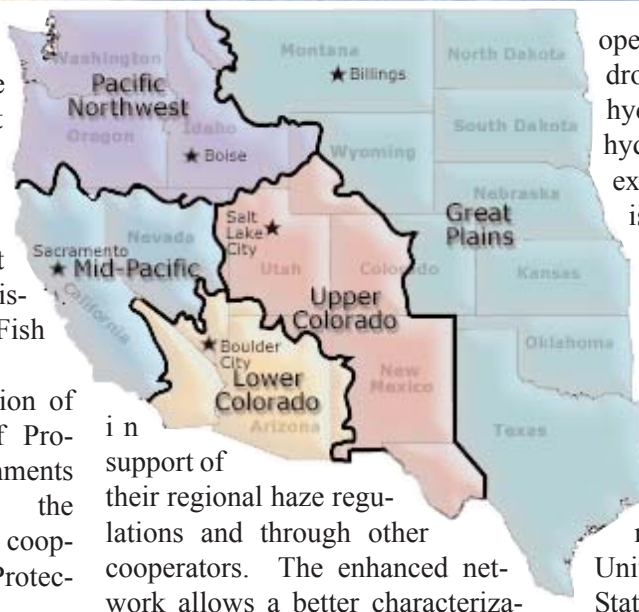
tion of visibility and fine particle concentrations throughout rural and remote areas of the country (Figure 3-DOI-5).

## BUREAU OF RECLAMATION

The Bureau of Reclamation (Reclamation) activities requiring the collection and use of meteorological data include water supply forecasting, snow-pack water equivalent assessment, river system management, reservoir

operations, irrigation scheduling, drought status assessment, flood hydrology, and projects related to hydroelectric energy resources. One example of such an ongoing activity is the Watershed and River System Management Program (WaRSMP), which is being developed in partnership with the USGS. Information on WaRSMP is at <http://www.usbr.gov/pmts/rivers/rsmgwtrmg.htm>.

Other key players in this effort include TVA, the Corps of Engineers, NOAA, NASA, NRCS, the University of Colorado and Colorado State University. This program pro-



in support of their regional haze regulations and through other cooperators. The enhanced network allows a better characteriza-

vides a data-centered framework for science-based water resources decision making. Major components are:

- Hydrologic Database (HDB),
- Modular Modeling System (MMS),
- RiverWare river system modeling framework,
- Stochastic Analysis, Modeling and Simulation (SAMS) system,
- Agricultural Water Resources Decision Support (AWARDS) and
- Evapotranspiration Toolbox (ET Toolbox) system.

#### HYDROLOGIC MODELING

The SAMS hydrologic modeling system is being used in WaRSMP to assist water resource managers in developing likely hydrologic scenarios for water supplies. It allows users to test various water resources management strategies, including extreme drought and high-flow scenarios which haven't been encountered in the historical period of record. Starting in FY 2005, the SAMS capabilities will be implemented on the Colorado River basin.

The RiverWare and HDB data-centered decision support system enables water managers to examine a variety of observed and forecast hydrologic scenarios using hourly, daily, or monthly data within the legal and physical constraints on operations of the river system. This model provides a holistic management tool for watershed and river systems, in order to meet a variety of competing demands for water.

Each new river system requires considerable development work (2-3 years) for RiverWare and HDB implementation. However, such a system can provide for efficient water operations management, and is especially useful during periods of drought and surplus - as demonstrated by the recent *Colorado River Interim Surplus Criteria: Final Environmental Impact Statement*.

Current Reclamation projects under

WaRSMP include:

- Planning and developing HDB, MMS and RiverWare systems for the Gunnison, San Juan, Rio Grande, Yakima, and Truckee river systems;
- Development of expanded capabilities to allow HDB to function as the Database of Record which will document management decisions and the data used to make them for Reclamation's Upper and Lower Colorado regions as well as other participating offices;
- SAMS integration and testing for the lower Colorado and Truckee River Basins;
- Implementing AWARDS systems to improve the efficiency of water management and irrigation scheduling for the Tualatin Project, Upper Columbia project areas, and Lower Colorado area;
- Developing the AWARDS/ET Toolbox system in the Middle Rio Grande and providing 24-hour water use estimates for input, via the Corps of Engineers' Hydrologic Engineering Center Decision Support System or a new HDB, to the Rio Grande RiverWare;
- Implementing similar AWARDS/ET Toolbox systems with input to local HDBs and RiverWare systems in the Upper Columbia, Lower Colorado, and possibly the Truckee-Carson areas;
- Integration and testing of emerging Land Surface Modeling Products from NASA's Global Land Data Assimilation Systems for snow mapping, surface energy and water budgets and ET analysis and prediction for water operations management; and
- Testing and development of weather and climate products from the Global Energy and Water Cycle Experiment (GEWEX) for water supply and demand forecasting.

#### INSTRUMENTATION AND DATA ACQUISITION

NEXRAD estimates of precipitation

are used for water supply and water delivery decision-making. Water managers can view the distribution of precipitation over watersheds that supply water to storage facilities, and examine the detailed spatial distributions of precipitation over the irrigated areas along with estimates of soil moisture, and evapotranspiration from crops and riparian vegetation.

The Watershed and River Systems Management Program focuses on integrating multi-disciplinary science into decision support systems that enable water managers to make the best deliveries of water to stakeholders.

Currently, Reclamation's HYDROMET system collects data from approximately 400 hydrometeorological data collection platforms (DCPs) which transmit data in real-time through GOES to Reclamation's DRGS in Boise, Idaho. AGRIMET is another network of 60 DCPs dedicated to analysis of crop water use and water conservation in the Pacific Northwest.

Data collected and products created in Boise are electronically transferred to other BLM, Federal and state offices. Reclamation's primary real-time hydrometeorological information from the NWS, USGS, NASA, and other agencies is displayed on the AWARDS / NEXRAD / ET Toolbox web site: <http://www.usbr.gov/pmts/rivers/awards/index.html>.

Water supply information from cumulative precipitation estimates from radar is also provided in areas where snow fall is an important source of water. Links directly to USDA Natural Resources Conservation Service and NOAA/National Centers for Environmental Prediction analysis and forecasting web sites are provided to further document the latest information.

#### TECHNICAL INFORMATION

The National Xeriscape Demonstration Program (NXDP) is nearing an end. The NXDP was initiated by



Reclamation to estimate the benefits of water conserving landscaping. In partnerships with States, field demonstration projects were conducted in Fargo ND, Austin TX, the Colorado Front Range, Phoenix AZ, and southern Nevada. Water savings ranged from 18 to over 50 percent in the demonstration projects, strongly suggesting water planners should consider this water conservation alternative as a supply development option.

**SNOWPACK ASSESSMENT.**

Snowmelt represents about 80 percent of reservoir storage in Colorado and is largely responsible for spring flooding events in the state. Therefore, it is highly desirable to know snowpack characteristics, such as its snow water equivalent (SWE), its spatial and elevation distribution, and its evolution with time during the water year. With support of the Colorado Water Conservation Board (CWCB), Reclamation has adapted the Snow Data Assimilation System (SNODAS) for enhanced snowpack assessment in the state of Colorado. The SNODAS was developed by the National Operational Hydrologic Remote Sensing Center (NOHRSC), a National Weather Service unit, and data are acquired through the National Snow and Ice Data Center.

SNODAS consists of a spatially distributed snow energy and mass balance model, coupled with an assimilation of all available SWE, snow depth, and snow cover data (from surface, aircraft, radar, satellite). Model outputs are at 1 km resolution and include SWE, snow depth, snowmelt, pack temperature, and sublimation. Comparison with data from Snow Telemetry (SNOTEL) sites and satellite imagery shows faithful representation of SWE and snow cover, respectively. Basin average SWE is substantially reduced over that of SNOTEL because the former is a basin-wide spatial average instead of an arithmetic average of a few high-elevation points. This dif-

ference is important hydrologically and holds the promise of coupling snowmelt with a hydrologic model to produce streamflow hydrographs. Such hydrographs would be extremely useful to the decision support systems of water management agencies such as

the CWCB and Reclamation, with the ultimate aim of improved forecasting of water supplies and flooding. Colorado SNODAS products have been posted daily at [http://www.usbr.gov/pmts/rivers/awards/SNODAS/SNODAS\\_CO\\_hist.html](http://www.usbr.gov/pmts/rivers/awards/SNODAS/SNODAS_CO_hist.html), since October

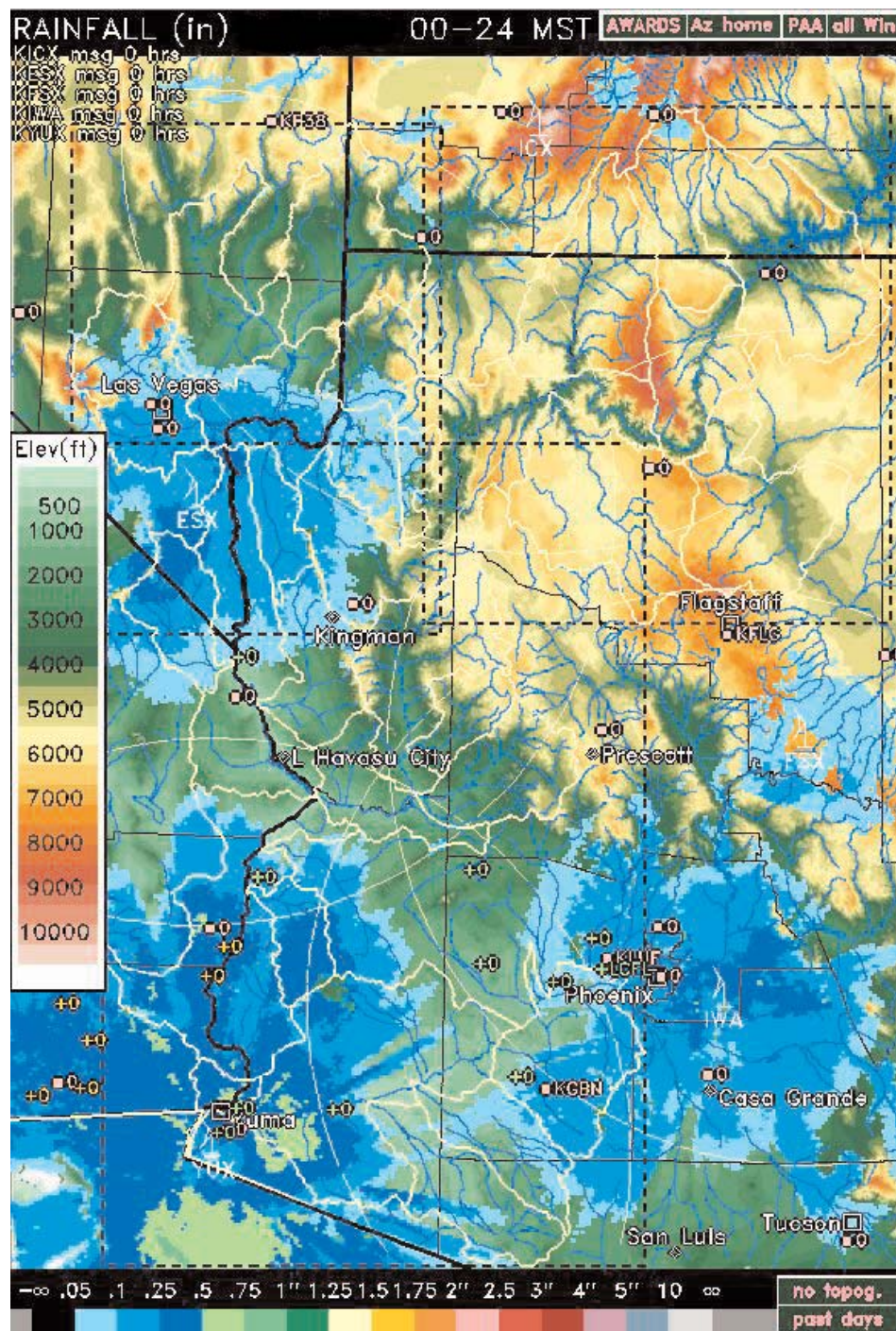


Figure 3-DOI-6. Agricultural Water Resources Decision-Support (AWARDS)/ET Toolbox example for the Lower Colorado River basin. AWARDS merges the precipitation accumulation algorithm (PAA) estimates from five WSR-88D (or NEXRAD) radars into a 2x2km grid.



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2003. Future work will consist of verification of SNODAS outputs, improvement of precipitation inputs, and coupling to a hydrologic model. An example of such an online product is given in Figure 3-DOI-6.

